are others that are nearly related; it has two rows of teeth on each side of the mouth, so have all its family; there are ten teeth in the front row and nine in the back; this is characteristic, but it would puzzle the best Latinist to put it in one word; and it has eleven gill openings, and this might be expressed by a compound Latin name which would be awkwardly long, and after all would not mean with eleven gill openings, but simply with eleven openings, so that on the whole I prefer *stoutii;* and stoutii, with the doctor's permission, it must be, unless some one has anticipated me in describing the fish.

Bdellostoma stoutii nov. sp. Eleven gill openings on each side; ten teeth in the anterior and nine in the posterior series. 15½″ long. Eel river, Humboldt county.

It is rather singular that this fish, which is abundant in Eel river, and is sold for food, and also occurs in this harbor, should hitherto have escaped notice. I believe it to be the only species of its genus hitherto found on the Pacific coast of North America; and it differs from *Bdellostoma polytrema,* a species which occurs along the coast of Chili, both in the number of its gill-openings and that of the teeth, *B. polytrema* having fourteen of the former and twelve of the latter in each series.

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THE BENEFICIAL INFLUENCE OF PLANTS.

BY J. M. ANDERS, M.D., PH.D.

A GOOD deal of attention has recently been given to the subject of the sanitary relations of plant life. Since plants constitute so great a factor in the organic world, a study of their functions necessarily becomes interesting and important. As every one knows, the knowledge of these processes is being rapidly unfolded, and clearly, the way to render this most useful is to examine into their practical relations; for our appreciation of plants and flowers must, to a great extent, go hand in hand with the increase in knowledge concerning their influence on our health and welfare. As our information in this direction increases we shall be more ready to acknowledge how much we owe to vegetation; still it is to be hoped that our ideas will never revert to the extravagant theories of the ancients, for we find that mythology credits trees with marvelous powers, such as their

being the abode of spirits, some of which were held sacred while others were supposed to be demonic. Trees were also supposed to be sentient beings and even possessed of souls. Strange as it may seem in this age of enlightenment, some relics of these ancient superstitions still linger in certain quarters of the globe.

Prof. Pettenkofer[1] has lately discussed the question of the hygienic relations of plants from a new standpoint, and has doubtless thrown new light upon it. He has, to his own satisfaction, demonstrated that three of the great functions in plants, namely, the giving off of oxygen, the absorption of carbonic acid and generation of ozone, really have no hygienic value whatever. The proof of his argument rests largely upon the solid basis of experimental researches conducted by himself and other noted investigators. It is but fair to say, however, that Prof. Pettenkofer does not deny *all* hygienic influence of vegetation, but attributes its influence to other circumstances rather than to the variation in the amount of the gases; and yet, in setting forth what he believes to be the sanitary operations of plants, he omits making any allusion to the process of transpiration as affecting the sanitary conditions of the air. This is not so surprising when we reflect how very imperfect our knowledge of this function has been up to a very recent date. In a paper on this subject we have presumed to attach more importance to this function.

We shall now make the proposition—a deduction from actual experiment—that the hygienic conditions of the air are both directly and indirectly affected by plant transpiration. It will be seen that the statement ventured contains two distinct elements, one implying the direct effect of transpiration on the air, the other the indirect; and it has been deemed best to discuss these elements separately in order to render the subject easier of comprehension.

The direct effect of transpiration might be formulated thus: In all atmospheres in which the proportion of aqueous vapor is less than the healthiest standard (about seven-eighths of what the air can contain at a given temperature), the beneficial influence of transpiration must be in proportion to the amount of aqueous vapor exhaled. In this connection the question naturally arises, What is the rate at which watery vapor is given off from plants? Here it will, perhaps, be pardonable to refer to the author's pre-

[1] Popular Science Monthly for February, 1878.

viously published experiments[1]; and, in order to establish this rate an extract from the summary of these investigations will be introduced, since they were instituted with the object of establishing the rate of transpiration:

In clear weather the evaporation by night, as compared to that which takes place in the day, appears to be about in the ratio of one to five. In some cases no loss occurred on dewy or cloudy nights. The camellia, however, lost nothing during clear nights, and gained in weight on dewy or rainy nights, even when kept indoors. Under ordinary circumstances evaporation at night was about the same indoors as in the open air.

The rate of transpiration during the day showed a very different relation, giving a ratio of two to one in favor of the open air. Of the whole amount evaporated during twelve hours, in the day experiments, half was given off between the hours of 11 A. M. and 3 P. M., as shown by repeated testing.

The following table, compiled for the number of clear days, will serve to exhibit the average rate of transpiration by day which took place in the open air during clear weather. It will also indicate the relation between leaf surface and the weight of the plant, and amount transpired. The mean temperature and average dew point have also been recorded in the table:

No.	Name of Plant.	Duration of Experiment	Average Evaporation.	Evaporating Surface.	Weight of Plant.	Average Temp.	Aver'e dew pt
1	Calla	12 hours	2850 grains	All parts green	2 lbs. 2 oz.	. . .	. . .
2	Geranium	"	3500 "	. . . .	4420 grains	. . .	. . .
3	Fuchsia.	"	1975 "	450 square in's	1920 "	64.5°	49.6°
4	Hydrangea	"	2858 "	744 "	2170 "	73	56.7
5	Camellia	"	710 "	479 "	. . . .	75.5°	63.3
6	Lantana	"	1717½ "	330 "	720 grains	75.1	61.7
7	Dracæna	"	2422 "	817 "	. . . . .	75.5	62

After an inspection of this table, the average rate of evaporation for soft thin-leaved plants, in clear weather, may be put down at about one and a quarter ounces per day (twelve hours) for every square foot of surface. The Lantana shows nearly two ounces to the square foot of surface. The camellia, with its dense smooth leaves, averaged less than half an ounce to the square foot of surface, per day.

* * * * * * A few calculations may serve to impress the importance of the ratio of transpiration deduced from these experiments. According to the above rate the Washington elm, at Cambridge, a tree, it is stated, of no very large size, with its 200,000 square feet of leaf surface, would transpire seven and three-quarters tons of watery vapor in twelve hours (day), clear weather.

Carrying the calculation further, a grove consisting of five hundred trees, each with a leaf surface equal to that of the elm mentioned, would return to the atmosphere 3906 tons of aqueous

[1] Compare this with journal for March, 1878, p. 160.

vapor in twelve hours. Even supposing this to be much over-estimated, it may very fairly be concluded from the facts given that the evaporation of watery vapor from plants is a powerful agent in maintaining the humidity of the surrounding air.

Some scientific critic might claim, as an objection to the latter assertion, that the amount of vapor exhaled from plants, though in itself large, is inconsiderable when compared with the evaporation from the surface of the earth. This seeming objection may, perhaps, best be confronted by a few calculations, and we first inquire what is the relative vaporization from a given area of leaf surface, and an equal area of earth surface? Taking the average rate of transpiration for soft, thin-leaved plants in clear weather to be one and a quarter ounces per square foot, and multiplying this by the number of days in a year the product would be twenty-seven pounds, or an equal number of pints. Now by reducing twenty-seven pints to cubic inches and dividing the result by the number of square inches in a square foot (144) we must obtain the depth in inches of the water transpired in the course of a year, about five and two-fifths inches. To continue our reckoning, we will next attempt to show the mathematical relation between the extent of the leaf surface of a section of country and the surface of the earth of the same section. According to the census returns for 1875, the percentage of woodland of the entire area of the United States, including Territories, water surfaces, cities, highways, etc., is 25; that is to say one-fourth of the total area is woodland. Now if we suppose every 900 square feet of forest land to contain one tree, and estimate each tree to be one-thirteenth the size (only) of the Washington elm, at Cambridge, we shall have about one-third of an acre of leaf surface for every tree; then it will not require much mathematical skill to understand that by multiplying the supposed leaf surface of each tree (one-third acre) by the number of trees per acre, and this in turn by the fraction one-fourth, or the proportion of woodland in the United States, the product will be four to one in favor of leaf surface over the total area of land surface. We have seen that according to our calculations the depth of transpiration per year for soft, thin-leaved plants is about five and two-fifths inches, but this must be an over-estimate, for the plants are actively giving off watery vapor only about five months of the year, that is, out of doors. We shall, therefore, suppose five-twelfths of five and two-fifths inches

or about two and one-fourth inches to be the yearly depth. Now if all the water transpired from this leaf surface were given off from a surface equal to that of the land area, we should find on a little reckoning that the depth of transpiration would be nine inches. It is to be remarked that transpiration from the grasses, cereals, underbrush, etc., was not considered in these calculations, but there can be no doubt as to their great assistance in this process; so that, were it possible to form anything like a correct estimate of the amount exhaled by these humble specimens of the vegetable kingdom the ratio would be greatly increased.

In our Southern States, many of which have as high as fifty per cent. of woodland, the depth for plant exhalation must be much greater, equivalent to at least eighteen inches, since the conditions are so much more favorable. All will agree that this is no mean showing for transpiration as affecting the proportion of moisture in the atmosphere, the yearly average rainfall being forty-three inches at Philadelphia.

There are evidently many inaccuracies in a computation like the foregoing, which it is exceedingly hard to avoid, but the allowances made will, it is hoped, meet the discrepancies and thus the true mark will not have been overreached.

Provided our reasoning be at all correct, the objection of our philosophic critic cannot have any weight, and the important fact remains established, that *transpiration is capable of increasing the humidity of the air.* Now, if transpiration so materially affects the quantity of the moisture in the outer air, what must be the effect of keeping plants in closed apartments? This question will here be discussed, and especially the effect of plants on the air of rooms heated by hot-air furnaces. According to the above extract it will be seen that the process is only about half as active indoors as in the open air, during the day, but at night the rate of transpiration is about equal in the two situations, so that during the whole twenty-four hours the quantity a plant would transpire indoors exceeds half what it would transpire in the open air, and we may presume from this fact alone that plants in rooms would influence the relative humidity of the air of the rooms.

From observations which I have made over a period of several weeks on the air of my private reading and sleeping room at the Episcopal Hospital (Philadelphia), which is kept warm by air heated by steam, and simultaneously on the air outside, it was

found that the air in the former position was appreciably dryer than the latter, the average complement of the dew point being on the whole about five degrees greater. The room adjoining mine, occupied by my colleague, was very kindly left for a time at my disposal; in it were kept a few plants in pots with a leaf surface of not more than twelve square feet. The dimensions of the rooms were similar, each being twenty feet long, eleven feet wide and sixteen feet high. Each had one window fronting east, in which the plants were kept. The average temperature and dew point in both these rooms were noted simultaneously, and the results showed uniformly, for a period of eighteen days, that the complement of the dew point averaged one and a half degrees less in the room containing the plants. These observations were made during the early part of April, 1878, when very little heat was required, still the windows were kept closed during the day. Calculating from these results, the effect of twenty-four square feet of leaf surface on the air of a room half the size of the above would be to increase the humidity sufficiently to raise the dew point six degrees Fahrenheit higher than it would be if there were no plants in the room. There can be no doubt but that a southern exposure of the plants would make the difference even greater.

As it seemed possible that the variation in the amount of moisture in the two rooms tested might be due to considerations other than the presence of plants, it was deemed necessary to vary the conditions and make further observations. Accordingly after placing some plants in the window of my own room, I took the average temperature and dew point, and compared them with those of an adjoining room containing no plants. No artificial heat was required during the time of these experiments. It was found that when the window was kept open so as to cause very free ventilation, no appreciable difference in the humidity of the two rooms was observed; but if the windows were closed for a few (say three) hours, it would make a difference of from one and a half to two degrees Fahr. in the complement of the dew point; the room having plants showing the lesser complement. This difference was maintained, almost, when the windows were opened just enough to allow a gradual interchange of the contained air; but as before intimated, a draft, though it might hasten transpiration, would, by carrying off the

vapor, prevent an increase of moisture in the air of the room. On days when the air was laden with moisture, no difference in the dew point was noticed, there being at such times little or no exhalation of watery vapor. The observations taken at 1 o'clock P. M., gave the greatest variation, the morning observations usually the least. We do not wish to say dogmatically that there is no possible chance of error in these experiments, but since they were corroborative throughout it seems fair to conclude that they are correct. Since it is allowable always to make logical deductions from facts, we may justly conclude, from the statements made in the above extract concerning the rate of transpiration, coupled with the carefully conducted observations here detailed, that during the summer months when the windows are thrown widely open and the doors kept ajar, the influence of transpiration is quite inconsiderable; on the other hand, when the interchange of air is not too rapid a sufficient number of plants, well watered, have the effect (if the air be not already saturated) of increasing the amount of moisture to a considerable extent.

As before intimated, it is my wish to apply the results of these researches particularly to the atmosphere of apartments heated by means of hot-air furnaces, which are known to be dryer than air heated by a stove or open fire-place. Not having the opportunity myself at the Hospital of comparing the dryness of air thus heated with that of the outer air, my wants were made known to a friend residing in a house heated by a dry-air furnace. Through the kindness of this friend reliable observations were made for a period of eight days. The results showed the mean average complement of the dew point to be seven degrees Fahr. greater for the heated air than the air outside. Now, according to our line of reasoning, a certain number of plants would bring up the humidity to that of the external air. Calculating from the above data, half a dozen each with a leaf surface of four square feet would be sufficient to produce this effect in a room twelve feet long and ten feet wide with a ceiling twelve feet high. The mean average temperature and dew point for the out-door observations were fifty-six degrees and forty-one degrees Fahr. respectively, which is a percentage still considerably below the healthiest standard. Some one, not a professional medical man, might pertinently ask: What is the effect on the system of air heated by a hot-air furnace? It will be necessary to answer this

inquiry only so far as relates to the effect of dry air at the ordinary temperature of such rooms.

If an apartment is heated to sixty-five or sixty-eight degrees Fahr., a person in good health and in ordinary clothing feels comfortable and experiences no immediate inconvenience. But the air contains a much smaller proportion of vapor than if the air were warmed to the same degree by a stove or open fire-place. In this manner a great demand is made upon the system to supply the air with moisture, the skin and pulmonary mucous membrane are dried, and a condition is induced which is expressed in irritability of the nervous system, paleness and susceptibility of the skin to cold, liability to pulmonary diseases, and, in a word, deterioration of all the functions.[1]

Now, it will not be doubted by any one, that if, as we have attempted to point out, the presence of a certain number of thrifty plants in an occupied apartment, warmed by dry air, would have the effect of raising the proportion of aqueous vapor to the extent indicated, plants in rooms heated by a hot-air furnace would in a hygienic point of view, be of very decided value, since they may become the means of obviating very distressing symptoms, or even disease itself. Indeed, the circumstance of so large a portion of the population of cities and towns using the hot-air furnace as a means of heating their dwellings would seem to justify the conclusion that there is a connection between their bodily ills and this method of heating, that one might be traceable, in part, to the other. It is true there are good uses of dry heat for the relief of certain diseases, but it requires a judicious application—a knowledge of the conditions in which it is indicated; it should be employed only when prescribed by a regular physician. In his very able paper, Prof. Pettenkofer wisely considers the impression which plants (and plantations) make upon our mind and senses to be of hygienic value. And, furthermore, he says: "I consider flowers in a room, for all to whom they give pleasure, to be one of the enjoyments of life, like condiments in food." May we not now rightfully consider plants kept in rooms under proper regulations to be of sanitary value also on account of their influence over the proportion of vapor in the air? And of the two effects is the latter not worthy of being made the paramount consideration? [2]

[1] Stillé Therapeutics, Vol. i, pp. 637–8.

[2] The following letter was received from my estimable friend as an acknowledgment of my paper on the Transpiration of Plants, which appeared in the March

Before passing to the consideration of moisture in the air as a means of lessening terrestrial radiation, which we have designated as the indirect effect of transpiration, it seems appropriate to give a place to a few of the laws governing radiation in general.

Radiation has been defined by Tyndall as a vibratory movement which begins in the ultimate particles of matter, and is propagated through waves of ether.

Different bodies absorb heat and radiate the same in degrees varying with their molecular constitution; that is to say, some bodies disturb the ether to a greater extent than others. It is an all important and universal law, that the power of a body to absorb heat and its power to radiate heat are reciprocal. Heat rays are emitted from both luminous and non-luminous bodies. The theory now almost universally accepted is, that heat and light are similarly transmitted; a ray which will give rise to the sense of heat by falling on the surface of the body will, if it fall on the retina, produce the sense of light, in general terms. Though the ray itself is the same in both instances, it is called, in the one case, a calorific ray, and in the other a luminous ray, on account of the effect produced. The only advantage in retaining these terms is convenience in communication. Bodies which allow the rays of light to pass freely through them are said to be transparent, on the other hand, bodies which allow radiant heat to pass through them are said to be diathermic. It

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number of this journal. The author of the letter not being aware, at the time of writing, that the present paper was in preparation.

J. M. Anders, M.D.

My Dear Dr:—I have read your "Transpiration of Plants" with much satisfaction. The amount of water exhaled is so greatly in excess of what I supposed to be the usual quantity, that it leads me to believe that the common opinion of physicians and laymen, that plants are injurious in the sick room, is wholly erroneous. I say the common opinion—I might say the universal opinion—for I have seldom, if ever, heard a favorable opinion of the practice expressed by any one; and yet I may not be well read in the literature of the subject, for, in your closing paragraph you say: "The practical advantage of keeping plants in occupied rooms, in which the air is generally drier than that outside, has also, from the results obtained, received further demonstration.".

I am tempted to ask you where you have ever seen the "advantage" of the practice spoken of? I speak now of plants in the sick room. Your paper has brought to me new thoughts, and carried me back over a practice of half a century to see what confirmation of the advantage of the practice I can bring forward. Physicians have often spoken to me against the habit of some people who have growing plants in the sitting room occupied by the family, and especially in rooms occupied by con-

is well known that the property of transmitting light is possessed by bodies in different degrees; their ability to transmit heat has been found to be equally diverse. Now the diathermancy of substances is greatly influenced by certain conditions, among which may be mentioned, more particularly, the nature of the molecules of the body, its thickness, and especially the source or kind of heat. The rays which are not transmissible through a body are absorbed by it, thus elevating the temperature of the body; when the body is perfectly diathermic, however, there is no elevation of temperature. Now, since the absorption and radiation of heat are reciprocal, it is interesting to know how the atomic constitution of the body is affected in these processes. The rays on striking a body are some of them absorbed and heat the atoms of the body, when each of these atoms acts as a heated body itself, and emits the rays absorbed, in all directions. It has been proved that absorption does not take place on the surface, but within the absorbing body, a certain thickness being necessary to effect the phenomenon.

As the substance with which we are most concerned is in the gaseous state—aqueous vapor in the air—we shall pass to the consideration of the radiation and absorption of gaseous substances. When we reflect that some solid and liquid bodies are almost or entirely diathermic, it would, at first sight, appear absurd to talk of gases absorbing and radiating heat. One would

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sumptive patients; but I have never heard any physician advise that plants should be placed in the sick chamber as a remedial measure. I hope your experiments will lead to a change of opinion on this subject—a change which you seem to anticipate—for if the exhalation really be so great, we have it in our power to regulate the amount of moisture in the sick room. Year after year new health resorts are urged on the public; abroad there are many; and in this country, from St. Augustine to Minneapolis, they are to be found in every State, the low, warm, moist places of the South, the cool mountain regions of the Middle States, and the cold, dry climate of Minnesota. Consumptives rush to every new place only to find, in a short time, that, like the others, it must be given up as useless. Science has no influence in the choice of places. Allow me to speak of a case which in this connection may interest you.

My mother, her two sisters and only brother all died of consumption under fifty years of age. On my father's side there was not a taint of any disease, but great strength and vigor. All the children of my mother's sisters and brother, though they lived to a good age and enjoyed good health, finally died of consumption. Three of my brothers, active, energetic men until within a few years of their death, died of consumption at the ages of 55, 57 and 78 respectively, and a sister died of the same disease at 66. I mention these cases to show that the germs of the disease were with the family. Thirty years ago my eldest sister, then above fifty years of age,

suppose from the circumstance that the spaces between the molecules are so much greater in the case of the gases than in solids or liquids, that no such thing as the interception of rays by these separate particles could occur. But recent, very ingenious and delicate experimentation by Prof. Jno. Tyndall has placed the fact beyond the domain of mere reasoning, that gases do intercept radiant heat, in other words, absorb and radiate calorific rays. It would be outside the limits of the present writing to describe the apparatus used and the methods pursued. Suffice it to allude to the results obtained by this investigator, and the conclusions arrived at by him. The correctness of these results will doubtless be readily conceded after a perusal of his admirable work on "Radiation," where everything is fully explained.

In experimenting with olefiant gas and sulphuric ether vapor, it was found that the densities of these two gases may be reduced vastly below that which corresponds to the atmospheric pressure, and still they were capable of arresting undulations of heat. On investigating some of the permanent gases, as carbon dioxide, nitrous oxide, etc., he found extreme variations in absorbent powers. The heat-absorbing capacity of hydrogen and of dry air were found to be inappreciably small, while carbon monoxide, carbon dioxide, etc., were found to be active absorbents. Considering the absorbing capacity of dry air one, that of carbon dioxide, would be ninety. Experiments with ozone place this

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was reported by her physician, Dr. J. P., a victim of tubercular consumption, to which disease she would succumb before the coming summer. She was a lover of plants and flowers, and cultivated them in-doors and out. The spring saw her again moving among her plants, and the winter found her confined to the house, and sometimes for weeks to her bed-chamber, which, like the sitting-room, was literally a green-house. Visitors and friends often spoke to her of the impropriety of having so many growing plants in her room, reminding her of the tradition that they were injurious. Still, every spring found her again on her feet, in the yard and garden, nursing her plants, and every winter confined to her room. And thus she lived, year after year, until two years ago when, at the age of 85, she passed away. I have seen a few others have plants growing and blooming in their chambers, but never one who so lived among them as did my sister. Winter after winter we looked for her death, the cough, expectoration and weakness justifying our apprehensions, and yet her 85th year found her cheerful and happy, living among her plants and enjoying the society of her friends. May we not believe that the vast exhalation from these plants—water purified and medicated by their vital chemistry—prolonged her life? The results of your experiments will awaken thought, and lead to observation on the influence of growing plants in the chambers of the sick. Truly your friend,

HIRAM CORSON.

substance in the foremost ranks as an interceptor of radiant caloric.

These researches by Prof. Tyndall were extended, also, to vapors of different bodies, such as sulphuric, boracic and formic ethers; and determined them to be highly active in interfering with calorific rays, boracic ether "exceeding any other substance hitherto tried." All the experiments above quoted are certainly of great scientific interest and importance; but happily this illustrious scientist did not omit to study the effect on radiation of the aqueous vapor constantly in our atmosphere. The quantity of vapor of water contained in the air is, however, very small indeed, constituting only about four and a half per cent., and, although the moisture is everywhere present, its ratio is very variable. It is perfectly invisible, so that by our senses we are quite unable to judge of the amount present; even the purest sky may contain a large proportion. As this vapor is to all intents and purposes a gaseous body, obeying the laws of gases, any one not familiar with the information which we have just outlined, would, doubtless, hesitate to accept the assertion that the watery vapor so sparsely scattered through the atmosphere is the main agent in regulating the nocturnal radiation from the earth's surface. Even Tyndall, himself, neglected for some time this substance; and, in his own phraseology, "could hardly credit the first result, which made the action of the aqueous vapor of the laboratory fifteen times that of the air in which it was diffused." But this result does not show the correct relation of the action of vapor and air; for after repeated experiments with air from different localities and examined similarly, the results were uniformly to the effect that vapor of water has an absorbing capacity seventy times that of the air in which it is contained. Many objections and criticisms, some of which seemed almost insurmountable, were overcome by varying the methods of procedure. The assertion made above, therefore, seems to have been fully and satisfactorily demonstrated by a most careful and competent experimentalist.

Still further testimony might be adduced, the result of observations of meteorologists. Col. Richard Strachey, an eminent meteorologist, made observations showing the relation between the tension of the aqueous vapor of the atmosphere and the fall of the thermometer during the night. A single statement taken

from his results will be sufficient for our purpose, namely: "When the tension of the vapor was 0.888 inches the fall of the thermometer was 6.0° Fahr., and when the tension was only 0.435 inches the fall amounted to 16.5° Fahr." It is fair to state that these observations were conducted long before Tyndall's researches with aqueous vapor, and are on this account all the more valuable. The evidence we have adduced seems to show conclusively, that the vapor forms a sort of invisible canopy separating the chilling air above from the warm earth beneath, and arresting, more or less effectually, the radiation. We have a homely illustration of this when we see the thrifty housewife spread coverings over the more delicate plants of her flower garden on nights when she fears a frost. It has been said that aqueous vapor is a blanket more necessary to the vegetable life of England than clothing is to man; and every plant capable of destruction by freezing would succumb, if this vapor were removed for a single night. In support of this assertion it will be well to notice the results obtained by some noted observers concerning the daily fluctuation in temperature in other countries. Dr. Livingston[1] has observed a great excess in nocturnal chilling when the air is dry over that which occurred when it is laden with moisture. He has found in the southern central portion of Africa, during the month of June, the thermometer early in the mornings at from 42° to 52° Fahr., at noon 94° to 96° Fahr., or a mean difference of forty-eight degrees between sunrise and mid-day. He says, furthermore: "The sensation of cold after the heat of the day was very keen. The Balonda at this season never leave their fires till nine or ten in the morning. As the cold was so great here, it was probably frosty at Linyanti; I therefore feared to expose my young trees there."[2] Crossing the continent, Dr. Livingston reaches the Zambezi at the commencement of the year. He gives the following description of the change felt on entering the valley of the river:

> We were struck by the fact that as soon as we came between the range of the hills which flank the Zambezi the rains felt warm. At sunrise the thermometer stood at from 82° to 86° Fahr.; at mid-day in the coolest shade, namely, in my little tent, under a shady tree, at 96° to 98° Fahr., and at sunset at 86° Fahr. This is different from anything we experienced in the interior.

[1] Livingston's Travels, p. 484.

[2] Livingston's Travels, p. 484.

Proceeding toward the mouth of the river (Jan. 16th), he makes the following additional observation:

The Zambezi is very broad here (at Zumbo) but contains many inhabited islands. On the 16th we slept opposite one called Shibanga. The nights are warm, the temperature never falling below 80°, it was 90° Fahr. even at sunset. One cannot cool the water by a wet towel round the vessel.[1]

Evidently the air was nearly saturated with moisture in the latter locality, and this affords the only explanation of the evenness of the temperature here.

In Australia the daily range of the thermometer is extremely great. The observations of Mr. W. S. Jevons[2] are of much interest, and we give an extract:

In the interior of the continent of Australia the fluctuations in temperature are immensely increased. The heat of the air, as described by Capt. Stewart, is fearful during summer; thus in about latitude 30° 50″ S., and longitude 141° 18′ E., he writes: "The thermometer every day rose to 112° or 116° in the shade, while in the direct rays of the sun from 140° to 150°." Again, "At a quarter past three, P. M., on January 21st (1845), the thermometer had risen to 131° in the shade and 154° in the direct rays of the sun. * * * In the winter the thermometer was observed as low as 24°, giving an extreme range of 107°" From these data we are not surprised to hear him remark further on, that, "The fluctuations of temperature were often very great and sudden, and were severely felt." He says, moreover, "It thus appears that even close to the ocean the mean daily range of the Australian climate is very considerable. It is least in the autumn and greatest during the cloudless days in spring." After giving here a table of the seasonal variation of the rainfall in Australia, Mr. Jevons says that, "It is plainly shown that the most rainy season of the year on the east coast is the autumn, that is, the three months, March, April, May. The spring season appears the driest, summer and winter being intermediate.

Prof. Tyndall says:[3]

Without quitting Europe we find places where, while the day temperature is very high, the hour before sunrise is intensely cold. I have often experienced this in the post-wagons of Germany; and I am informed that the Hungarian peasants, if exposed at night, take care, even in hot weather, to protect themselves by heavy cloaks against the nocturnal chill.

All this evidence should be sufficient to convince the most

[1] Livingston's Travels, p. 575.

[2] Quoted by Tyndall.

[3] Discourse on radiation through the Earth's Atmosphere.

skeptical that aqueous vapor furnishes a very effectual barrier to terrestrial radiation.

The tropical torrents can be accounted for by the property vapor has to absorb and radiate heat, thereby condensing the vapor raised from the equatorial regions through the direct rays of the sun. But it is only the upper strata of the vapor bed covering the surface of the earth, which by radiating into open space produces the effect above stated. Owing to the same quality may be explained the formation of cumuli; the theory of sereim, or the falling of the exceedingly fine rain shortly after sunset in the fine season. These and many other meteorological phenomena receive their solution from the development of this property of aqueous vapor. Every one will readily acknowledge that a question affecting so materially important sciences as the one under consideration, should be quite definitely settled, and it is for this reason that so much stress, by way of testimony, has been here placed upon it.

Admitting then that the vapor in the air does, by the property above discussed, influence numerous climatic conditions, the sources of this vapor certainly should claim a larger share of attention.

Nature's chief means of furnishing this moisture is through vaporization from the ocean, especially in the tropics; but many tracts of country inland, or even near the great seas, do not, for some reason, contain sufficient moisture. Now, if by any means at our command we can assist nature in supplying this very essential substance, it would be well worth our endeavors. Here the question presents itself, "Is there any connection, all things considered, between the proportion of moisture in the air and forest growth?" This question has been the subject of a great deal of discussion among able scientists, and we believe the balance of argument is in favor of the theory that there is a relationship existing between vegetation and the humidity of the air. The writer hopes he may have been successful in showing that a large proportion of the atmospheric vapor may be accounted for through the process of transpiration from plant life, that is, where there exists a fair percentage of woodland, say from twenty-five to thirty per cent.; so that now the above query may, we think, be answered in the affirmative. Under these circumstances the practice of forest culture as a means of improving atmospheric conditions, cannot be too highly commended.